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(54) Abstract Title
A vehicle 'steer-by-wire' system using redundant control systems

(57) A 'steer-by-wire' system for vehicles which can be operated in either normal or emergency mode. In normal mode, a steering handle (5) and steered vehicle wheels (2) are connected to one another via a control system. In emergency mode, the steering handle (5) and the steered vehicle wheels (2) are mechanically and/or hydraulically positively coupled. The steering system has a steering angle control unit (1) and a manual torque control unit (33). Control unit (1) contains a first steering angle control system for a steering angle actuator (19) which actuates the steered vehicle wheels (2). Control unit (33) contains a first manual torque control system for a manual torque actuator (35) which actuates the steering handle (5) for the purpose of simulating manual torques. The control unit (1) also contains a second manual torque control system which is connected redundantly with the first manual control system and control unit (33) also contains a second steering angle control system which is connected redundantly with the first steering angle control system. The control units monitor themselves and the steering system for functional reliability and perform switching between normal and emergency modes.

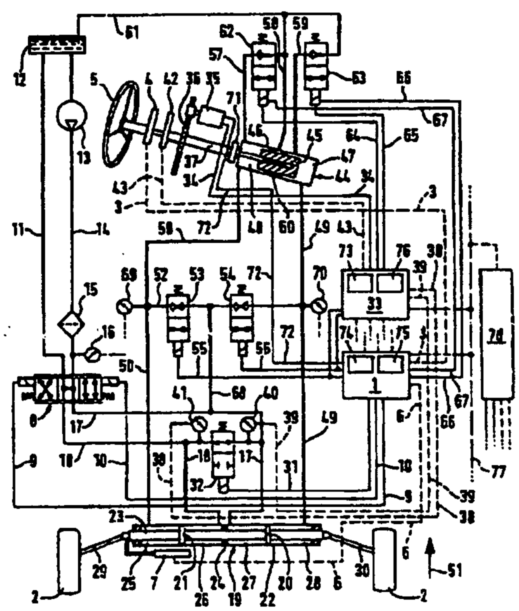

Fig. 1

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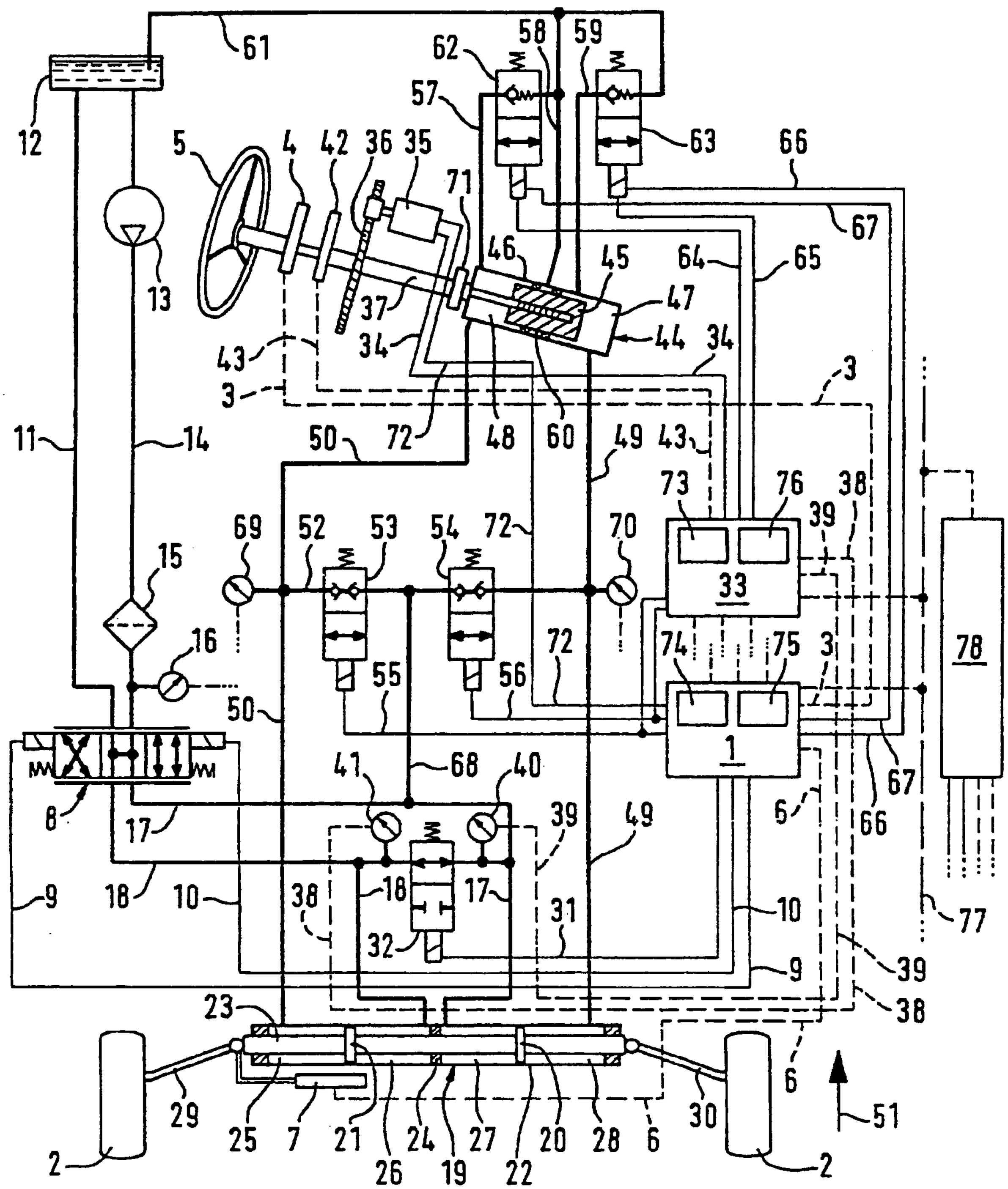
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Fig. 1

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Steering system for a vehicle

The invention relates to a steering system for vehicles, operable in a normal mode, in which a steering handle (wheel) and steered vehicle wheels are connected to one another via an electric or electronic control system (steer-by-wire level), and in an emergency mode, in which the steering handle and the steered vehicle wheels are positively coupled mechanically and/or hydraulically (fall-back level).

A steering system of this kind generally has a control unit which continuously monitors the functionality of the steer-by-wire components of the steering system and, in particular, checks redundantly available information for plausibility. As soon as the control unit detects a fault, it switches from normal mode to emergency mode to enable higher operational reliability to be ensured for the vehicle. The so-called "fall-back level" of the steering system, i.e. the mechanical and/or hydraulic positive coupling which is activated in the emergency mode between the steering handle and the steered vehicle wheels, can be formed, for example, by means of a conventional steering line containing a clutch by means of which the mechanical steering line can be activated for emergency operation. As an alternative to a mechanical steering line, hydraulic positive coupling by means of a so-called "hydraulic rod" can also be provided. A hydraulic rod of this kind has a manual-side, first piston-cylinder unit, the piston of which is displaced axially in the associated cylinder by actuation of the steering handle, hydraulic fluid being displaced out of a chamber formed by the piston in the cylinder and fed to a wheel-side, second piston-cylinder unit. The hydraulic fluid displaced out of the first piston-cylinder unit displaces the associated piston in the second piston-cylinder unit, this piston being coupled mechanically to the steered vehicle wheels, with the result that these turn.

DE 196 22 731 A1 has disclosed a hydrostatic steering device which has two control systems. Each of these control systems has a hydraulic pump, a servo valve and a servomotor. The servo valves are actuated by means of a common steering wheel. The known steering device furthermore has a change-over valve which, in its operating position, hydraulically connects the motor lines of the second control system and, in an emergency position, hydraulically connects the motor lines of the first control system. Also provided is an actuating device which responds when a fault occurs in the first control system and switches the change-over valve from the operating position into the emergency position. With the known steering device,

...erefore, servo-assisted steering is possible even if the first control system fails. A steering device of this kind, which has two complete, separately operating control systems, is relatively expensive.

The present invention concerns itself with the problem of specifying a configuration for a steering system of the type stated at the outset which increases the operational reliability of the steering system by simple design measures.

According to the present invention there is provided a steering system for a vehicle, operable in a normal mode, in which a steering handle actuatable by the driver, and steered vehicle wheels are connected to one another via an electric or electronic control system (steer-by-wire level), and in an emergency mode, in which the steering handle and the steered vehicle wheels are positively coupled mechanically and/or hydraulically (fall-back level), the system having a steering-angle control unit for a steering-angle actuator, which actuates the steered vehicle wheels, the said control unit containing a first steering-angle control system which compares the actual steering-angle values from an actual steering-angle transmitter actuated with the steered vehicle wheels and desired steering-angle values from a desired steering-angle transmitter actuated with the steering handle and, as a function thereof, actuates the steering-angle actuator, and having a manual-torque control unit for a manual-torque actuator which actuates the steering handle for the purpose of simulating manual torques, the said control unit containing a first manual-torque control system, which generates desired manual-torque values correlated with the forces acting at the steered vehicle wheels and compares them with actual manual-torque values from an actual manual-torque transmitter actuated with the steering handle and, as a function thereof, actuates the manual-torque actuator, the control units monitoring themselves and the steering system for functional reliability and plausibility and switching between the normal mode and the emergency mode of the steering system as a function of this monitoring, the steering-angle control unit comprising a second manual-torque control system, which is connected redundantly with the first manual-torque control system of the manual-torque control unit, and the manual-torque control unit comprising a second steering-angle control system, which is connected redundantly with the first steering-angle control system of the steering-angle control unit

The invention is based on the general idea of providing a first control unit (steering-angle control unit) for the steer-by-wire level, the said control device being

intended for the actuation of a wheel-angle actuator, and a second control unit (manual-torque control unit) for simulating manual torques at the steering handle, the control units in each case being configured in such a way that each control unit can additionally perform sub- functions or even all functions of the other control unit, there thus being a redundant control unit available for each control unit. Since the control units preferably operate in a computer-assisted manner and are thus programmable, additional functions can be integrated into the control units with little effort by altering the programming. The fail-safety of the steering system is significantly improved by the proposal according to the invention.

According to a particularly advantageous embodiment of the steering system according to the invention, the control units and the sensors assigned to them are connected to one another via a databus. This allows complete information exchange between the control units and the respectively assigned sensors with little outlay.

In a particularly advantageous embodiment of the steering system according to the invention, the steering system can be operated in a maintained-comfort emergency mode, in which servo assistance is provided for the mechanical and/or hydraulic positive coupling of the fall-back level, this servo assistance reducing the manual torques required to actuate the steering handle and thereby facilitating steering actuation of the steering handle. The servo assistance is preferably implemented by means of still-functional elements of the steer-by-wire level of the steering system. For example, servo assistance can be provided by the manual-torque actuator which, given appropriate control, reduces the manual torques required for steering actuation by virtue of its coupling to the steering handle.

In the case of a steer-by-wire level operating with a hydraulic servo motor for example and of a hydraulically positively coupled fall-back level, appropriate coupling of the hydraulic systems can be employed to enable the hydraulic circuit provided for the actuation of the servo motor to be used for servo assistance for the hydraulic positive coupling of the fall-back level.

The steering characteristics of the vehicle in normal mode differ very markedly from those in emergency mode as regards the required manual torques to be applied by the driver at the steering handle, with the result that a change between the operating states during a journey, particularly while cornering, is dangerous. Thanks to the maintained-comfort emergency mode according to the invention, the steering system provides an operating mode for a (partial) failure of the steer-by-wire level

that corresponds essentially to conventional servo-assisted steering. The transition between the normal mode and the maintained-comfort emergency mode can be designed in such a way that it is not noticed by the driver. However, it is expedient to give the driver a corresponding warning encouraging him to visit a garage soon.
Only small structural measures need to be carried out to implement a servo-assisted maintained-comfort emergency mode of this kind.

Another important idea of the steering system according to the invention is regarded as the fact that the control units of the steering system have access to parameters, data, signals and the like of other electrical or electronic vehicle components so that they can generate information (signal values) from these which are redundant relative to the information (signal values) which is generated by the sensors assigned to the control units. This flow of information can be implemented in a particularly simple manner if the control units are connected via a databus to a vehicle computer in which the above mentioned vehicle operating parameters are available or to which these parameters are supplied.

Further important advantages and features of the steering system according to the invention will become apparent from the subclaims, the drawing and the associated description of the figures with reference to the drawing.

It goes without saying that the abovementioned features to be explained below can be employed not only in the respective combination given but also in other combinations or on their own without departing from the scope of the present invention.

A preferred embodiment of the invention is illustrated in the drawing and is explained in greater detail in the description which follows. In the drawing:
Fig. 1 shows a basic diagrammatic representation of a steering system according to the invention.

According to Fig. 1, the steering system has a steering-angle control unit 1 which is used to actuate steered vehicle wheels 2. The steering-angle control unit 1 is connected by a signal line 3 to a desired steering-angle transmitter 4 coupled to a steering handle designed as a steering wheel 5. The steering-angle control unit 1 is furthermore connected, by a signal line 6, to an actual steering-angle transmitter 7. The steering-angle control unit 1 carries out a comparison between the desired and the actual values for the steering angles and, as a function thereof, switches a control valve 8 to which it is connected by corresponding switching lines 9 and 10.

On the one hand, the control valve 8 is connected via a return line 11 to a hydraulic-fluid reservoir 12 and via a hydraulic line 14 to the delivery side of a hydraulic pump 13, the inlet side of which is likewise connected to the hydraulic-fluid reservoir 12. Between the hydraulic pump 13 and the control valve 8, the hydraulic line 14 also contains a pressure filter 15 and a pressure-measuring device 16. On the other hand, the control valve 8 is connected via pressure lines 17 and 18 to a servo motor 19 designed as a piston-cylinder unit. If the power fails, the control valve 8 assumes the position illustrated in Fig. 1, in which all the connections of the control valve 8 are short-circuited.

The servo motor 19 has two pistons 20 and 21, which are fixed to a piston rod 23 passing axially through a cylinder 22 of the servo motor 19. An axial dividing wall 24, through which the piston rod 23 passes, is formed in the cylinder 22 between the pistons 20 and 21, with the result that a total of four chambers 25, 26, 27 and 28 are formed in the cylinder 22 of the servo motor 19. In this arrangement, the chambers 26 and 27 arranged on each side of the dividing wall 24 are pressurized by the pressure lines 17 and 18 of the control valve 8 in order to displace the pistons 20 and 21 and hence the piston rod 23 axially. The piston rod 23 is coupled to the steered vehicle wheels 2 by steering rods or track rods 29 and 30, with the result that an axial displacement of the piston rod 23 results in a steering adjustment of the steered vehicle wheels 2.

The steering-angle control unit 1 is furthermore connected by a switching line 31 to a first safety valve 32 which, when de-energized, occupies the position illustrated in Fig. 1, in which the pressure lines 17 and 18 are short-circuited. For steer-by-wire operation of the steering system, the steering-angle control unit 1 switches the first safety valve 32 into the other position, in which the pressure lines 17 and 18 are separated from one another.

To enable the steering-angle control unit 1 to perform all the functions assigned to it, it is equipped with a first steering-angle control system 74. This can be designed as a circuit or as a program.

In order to give the driver a feeling for the side forces acting on the steered vehicle wheels 2, the steering system has a manual-torque control ~~unit 33~~, which actuates a manual-torque actuator 35, designed as an electric motor, via a switching line 34. This manual-torque actuator 35 is coupled directly or by way of a gear 36 to a steering spindle 37 which is actuated by the steering wheel 5 and is supported at 71.

The manual-torque control unit 33 is furthermore connected by signal lines 38 and 39 to two pressure-measuring devices 40 and 41, of which one pressure-measuring device 40 communicates with one pressure line 17 and the other pressure-measuring device 41 communicates with the other pressure line 18. In this way, the manual-torque control unit 33 can determine pressure differences between the chambers 26 and 27 and, from these, can determine the side forces acting on the steered vehicle wheels 2. As a function of the side forces determined, the manual-torque control unit 33 generates a desired manual-torque value that is to take effect at the steering wheel 5. To simulate this manual torque at the steering wheel 5, the manual-torque actuator 35 is actuated in an appropriate manner. In this arrangement, the steering spindle 37 is coupled to an actual manual-torque transmitter 42, which is connected by a signal line 43 to the manual-torque control unit 33. The manual torque transmitted to the steering wheel 5 by the manual-torque actuator 35 is regulated by comparing the desired values and actual values for the manual torques.

To enable the manual-torque control unit 33 to perform all the functions assigned to it, it is equipped with a first manual-torque control system 73, which can be designed as a circuit or a program.

For emergency operation, i.e. for the eventuality that the steer-by-wire level is defective, the steering system has an emergency or fall-back level, on which there is mechanical and hydraulic positive coupling between the steering handle 5 and the steered vehicle wheels 2. For this purpose, the steering spindle 37 actuated by the steering handle 5 is coupled to a piston-cylinder unit 44. In this arrangement, the axial end of the steering spindle 37, the said end interacting with the piston-cylinder unit 44, is designed as a spindle drive which interacts with a piston 45 of the piston-cylinder unit 44 in such a way that rotary displacements of the steering spindle 37 result in an axial displacement of the piston 45 in a cylinder 46 of the piston-cylinder unit 44. In the cylinder 46, the piston 45 axially separates two chambers 47 and 48 which are connected by hydraulic lines 49 and 50 to axially outer chambers 25 and 28, respectively, of the servo motor 19. Since the hydraulic system for this positive coupling between the steering handle 5 and the steered vehicle wheels 2 is sealed off and since the hydraulic fluid is essentially incompressible, the right-hand chamber 47 of the piston-cylinder unit 44, the right-hand chamber 28 of the servo motor 19 and the right-hand hydraulic line 49 connecting these chambers 47 and 28 to one another (the term "right-hand" referring to the direction of travel symbolized by an arrow 51)

referred to as the "right-hand hydraulic rod". Similarly, the left-hand chamber 48 of the piston-cylinder unit 44, the left-hand chamber 25 of the servo motor 19 and the left-hand hydraulic line 50 connecting them are referred to as the "left-hand hydraulic rod".

The left-hand hydraulic line 50 can communicate with the right-hand hydraulic line 49 via a connecting line 52. For this to happen, however, a second safety valve 53 and a third safety valve 54 must be actuated accordingly. The second safety valve 53 and the third safety valve 54 are connected by switching lines 55 and 56 to the steering-angle control unit 1 and the manual-torque control unit 33. In Fig. 1, the second and the third safety valves 53 and 54 are in their de-energized position, a position they assume automatically for emergency operation. In this position, the connections of the safety valves 53 and 54 are shut off and the hydraulic lines 49 and 50 thus do not communicate with one another via the connecting line 52.

To enable the functional reliability of the fall-back level to be guaranteed, three bleed lines 57, 58 and 59 are connected to the piston-cylinder unit 44, these bleed lines forming the geodetically highest points of the hydraulic system of the fall-back level. Bleed line 58, which communicates with an annular space 60 in the cylinder 46, the said annular space being formed between chambers 47 and 48 and being relatively unpressurized, is connected continuously to the hydraulic-fluid reservoir 12 by a return line 61. In contrast, bleed lines 57 and 59, which communicate with the pressurized chambers 46 and 47, can only be connected to the return line 61 via bleed valves 62 and 63. On the one hand, the bleed valves 62 and 63 can be actuated via switching lines 64 and 65 by the manual-torque control unit 33 and via switching lines 66 and 67, separate therefrom, by the steering-angle control unit 1.

The pressurization of the hydraulic rods and the hydraulic positive coupling of the fall-back level are performed via a hydraulic coupling line 68 which is connected to the connecting line 52 between the second and the third safety valves 53 and 54 and connects the said connecting line to the pressure line 17. This allows the left-hand hydraulic line 50 or the right-hand hydraulic line 49 or both to be connected to the delivery side of the hydraulic pump 13 by appropriate operation of the safety valves 53 and 54 and of the control valve 8.

Communicating with the hydraulic lines 49 and 50 are pressure-measuring devices 69 and 70, by means of which the control units 1 and 33 respectively, can check the leak tightness of the hydraulic system of the fall-back level.

In a preferred embodiment, the control units 1 and 33 and all the sensors (e.g. pressure-measuring devices, actual/desired value transmitters) are connected by a common databus. On the one hand, this considerably simplifies the arrangement of the signal lines and, on the other hand, it also gives each component access to all the information which is transported on the bus. Particularly when one or more databuses are used to connect the components of the steering system, the correspondingly designed or correspondingly programmed control units 1 and 33 can complement or substitute for one another. For this purpose, the steering-angle control unit 1 contains a second manual-torque control system 75, which can perform all the functions of the manual-torque control unit 33 and can be designed as a circuit or as a program. The manual-torque control unit 33 furthermore contains a second steering-angle control system 76, which can perform all the functions of the steering-angle control unit 1 and can be designed as a circuit or as a program. To enable the control units 1 and 33 to complement and substitute for one another with regard to their switching functions as well, separate amplifiers are preferably provided to make available the switching power for the elements to be switched, e.g. valves and control elements.

It is expedient if, together with the manual-torque actuator 35, the manual-torque control unit 33 forms a subassembly which can be installed together and is installed in the vehicle in the region of a dashboard, for example, in the vicinity of the steering handle 5. The actual manual-torque transmitter 42 is then also situated in proximity to this subassembly or integrated into it. Only the pressure-measuring devices 40 and 41 are arranged in the vicinity of the servo motor 19, making it necessary to lay cables in the vehicle to make the connection with the manual-torque control unit 33, at least for the signal lines 38 and 39. The steering-angle control unit 1 is also generally combined with the servo motor 19 to form a subassembly which can be installed together but is fitted on the vehicle in the region of the steering linkage 29, 30, in the vicinity of the steered vehicle wheels 2. It is also expedient for the actual steering-angle transmitter 7 to be integrated into this subassembly. The control valve 8 and the entire hydraulic circuit for the actuation of the servo motor 19 can likewise be accommodated in the vicinity of the latter. Only the desired steering-

angle transmitter 4 is arranged in the region of the steering handle 5, making it necessary to lay one cable in the vehicle at least for the signal line 3.

The reciprocal redundancy of the control units 1 and 33 can be achieved in a particularly simple manner without a high outlay in terms of design. If standardized programmable components are used for the control units 1 and 33, it is essentially a matter of programming whether control unit 1 or control unit 33 is used to actuate the manual-torque actuator 35 or to actuate the steering-angle actuator (servo motor 19). Accordingly, it is also possible for the control units 1 and 33 to be designed, more particularly programmed, in such a way that they can be used both to actuate the manual-torque actuator 35 and the steering-angle actuator 19. Since cables for the signal lines 38 and 39 for connecting the pressure-measuring devices 40 and 41 to the manual-torque control unit 33 and for the signal line 3 for connecting the desired steering-angle transmitter 4 to the steering-angle control unit 1 have to be laid in any case, a databus can be laid instead without any additional outlay, with the result that, on the one hand, both control units 1 and 33 can call up the signal values of all the sensors and, on the other hand, all or some of the switching elements can be actuated via power cables laid from both control units 1 and 33 to the switching elements. In this way, the control units 1 and 33 can support and substitute for one another. The configuration according to the invention increases the safety of the steering system.

In a preferred configuration, the switching elements which can be actuated by the two control units 1 and 33, e.g. valves, electric motor, electric clutch in a steering line, are equipped with separate windings, each of which is assigned to one of the control units 1 and 33. For example, the valves each have two actuating magnets that can be switched separately and independently. This improves fail-safety, particularly as regards short-circuit proofing.

According to a particularly advantageous embodiment of the steering system according to the invention, the control units 1 and 33 can operate the steering system in a maintained-comfort emergency mode in the event that only some parts of the steer-by-wire level of the steering system are operating incorrectly, this mode operating essentially like a conventional servo-assisted steering system with positive coupling between the steering handle 5 and steered vehicle wheels 2. If, for example, the control valve 8 sticks, the safety valves 32, 53 and 54 are switched to the position shown in Fig. 1, with the result that the steering actuation of the steered vehicle wheels 2 takes place as a function of the axial displacement of the piston 45 in the

manual-side piston-cylinder unit 44. To ensure that the driver does not have to supply by hand, at the steering wheel 5, the entire manual torque required for a steering adjustment of the steered vehicle wheels 2, the manual-torque actuator 35 is used as the means of servo assistance in this maintained-comfort emergency mode, for which purpose the said actuator is driven in an appropriate manner by the manual-torque control unit 33 via switching line 34 or by the steering-angle control unit 1 via a switching line 72.

In the case of another defect, the control valve 8 and the safety valves 53 and 54 can be controlled by the control units 1 and 33 in such a way that the wheel-side piston-cylinder unit (servo motor 19) is actuated hydraulically as a function of the actuation of the steering handle 5 and hydraulic servo assistance is obtained in this way for the axial displacement of the piston 45 and for the piston rod 23 of the servo motor 19.

Only if those components of the steer-by-wire level which can be used for servo assistance fail must the steering system according to the invention be operated in emergency mode without servo assistance.

Another important aspect of the steering system is regarded as being that, on the one hand, the hydraulic system of the fall-back level (the hydraulic rods) is bled via the bleed valves 62 and 63 at regular intervals during the normal operation of the steering system, allowing functional impairments of the fall-back level to be eliminated. On the other hand, tests on the leak tightness of the hydraulic components of the fall-back level are carried out at regular intervals, and it is possible to check the left-hand hydraulic rod independently of the right-hand hydraulic rod. In this way, any leaks that may be present can be located relatively accurately. If the steering system or its control units 1 and 33 detects/detect a malfunction on the fall-back level, this can be indicated to the driver. In any event, this malfunction is indicated at the next vehicle service. Depending on the safety concept, provision can also be made for the maximum speed of the vehicle, its range or the like to be limited in this case. For example, the vehicle will only be allowed to drive at low speed to the nearest garage.

If the control units 1 and 33 communicate via a bus 77, for example, with one or more vehicle computers 78 the information acquired and processed by the respective computer can be used by the control units 1 and 33 to perform plausibility checks or to obtain redundant signals for failed sensors or their signals.

Claims

1. A steering system for a vehicle, operable in a normal mode, in which a steering handle actuatable by the driver, and steered vehicle wheels are connected to one another via an electric or electronic control system (steer-by-wire level), and in an emergency mode, in which the steering handle and the steered vehicle wheels are positively coupled mechanically and/or hydraulically (fall-back level), the system having a steering-angle control unit for a steering-angle actuator, which actuates the steered vehicle wheels, the said control unit containing a first steering-angle control system which compares the actual steering-angle values from an actual steering-angle transmitter actuated with the steered vehicle wheels and desired steering-angle values from a desired steering-angle transmitter actuated with the steering handle and, as a function thereof, actuates the steering-angle actuator, and having a manual-torque control unit for a manual-torque actuator which actuates the steering handle for the purpose of simulating manual torques, the said control unit containing a first manual-torque control system, which generates desired manual-torque values correlated with the forces acting at the steered vehicle wheels and compares them with actual manual-torque values from an actual manual-torque transmitter actuated with the steering handle and, as a function thereof, actuates the manual-torque actuator, the control units monitoring themselves and the steering system for functional reliability and plausibility and switching between the normal mode and the emergency mode of the steering system as a function of this monitoring, the steering-angle control unit comprising a second manual-torque control system, which is connected redundantly with the first manual-torque control system of the manual-torque control unit, and the manual-torque control unit comprising a second steering-angle control system, which is connected redundantly with the first steering-angle control system of the steering-angle control unit.

2. A steering system according to Claim 1, wherein one or more databuses are provided, to which the control units and sensors assigned to the latter are connected.

3. A steering system according to Claim 2, wherein at least one further vehicle control unit is also connected to the databus or databuses.

4. A steering system according to any one of Claims 1 to 3, wherein the control units check the mechanical and/or hydraulic positive coupling of the fall-back level for functionality during normal operation.

5. A steering system according to any one of Claims 1 to 4, wherein the mechanical and/or hydraulic positive coupling of the fall-back level has a manual-side piston-cylinder unit which is actuated mechanically with the steering handle and hydraulically actuates a wheel-side piston-cylinder unit which, for its part, mechanically actuates the steered vehicle wheels.

6. A steering system according to Claims 4 or 5, wherein, to check the functionality of the fall-back level, the control units check a hydraulic circuit of the positive coupling for leak tightness and/or the system pressure level prevailing.

7. A steering system according to Claim 4, wherein the positive coupling has a mechanical steering line divisible by means of an electrically or hydraulically actuated clutch, and, for function checking, proximity switches are provided which respond when the clutch is closed briefly on a routine basis, and/or, for function checking the electric clutch, its current and/or voltage supply is tested, and/or, for function checking the hydraulic clutch, pressure sensors are provided which monitor the minimum permissible opening pressure.

8. A steering system according to any one of Claims 1 to 7, wherein the control units are adapted to operate the steering system in a maintained-comfort emergency mode, in which servo assistance is provided for the mechanical and/or hydraulic positive coupling of the fall-back level.

9. A steering system according to Claims 5 and 8, wherein the steering-angle actuator comprises a hydraulic servomotor which is actuated by a servo valve connected to a hydraulic pump, and servo-assistance in the maintained-comfort emergency mode is provided by the hydraulic circuit of the servo motor, which in this case is hydraulically coupled to the piston-cylinder units of the positive coupling and provides servo-assistance for their actuation.

... A steering system according to Claim 8 or 9, wherein the servo assistance is provided by the manual-torque actuator, which in this case assists actuations of the steering handle.

11. A steering system according to any one of Claims 1 to 10, wherein the control units are connected via a databus to a vehicle computer, to which further sensors are connected, and use vehicle operating parameters available there to generate signals which are redundant relative to the signals which are generated on the basis of measured values of at least one sensor assigned to the control units.

12. A steering system according to any one of Claims 1 to 11, wherein separate independent switching lines are provided which connect each control unit to one or more switching elements, which can thus be actuated by both control units.

13. A steering system according to Claim 12, wherein the switching elements which can be actuated by both control units each have two windings which can be energized separately to actuate the respective switching element and one of which is assigned to one control unit and the other is assigned to the other control unit.

14. A steering system for a vehicle, substantially as described herein with reference to, and as illustrated in the accompanying drawings.

Application No: GB 9921710.1 **Examiner:** Anthony Guile
Claims searched: 1-13 **Date of search:** 23 November 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): B7H (HHA, HHD, HHT, HXB, HXG)

Int Cl (Ed.6): B62D 6/00, 5/04, 5/06, 5/093, 5/30, 5/32

Other: Online: WPI, EPODOC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB 2308107 A	(MERCEDES-BENZ AG) See fig. 1 and page 8 para. 3 - page 9 para. 2.	1,2,3,5, 11,12
Y	GB 2259892 A	(HONDA) See fig. 2, page 6 lines 19-31 and page 7 lines 15-21.	1,5,12
Y	US 5747950	(DANFOSS A/S) See fig. 1, column 3 lines 35-56, column 5 lines 58-61 and column 6 lines 14-25.	1,2,3,5, 11,12

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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